



Evaluation and Selection of Cloud Service: A neutrosophic model

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Abstract

The variety of cloud-based services that are now accessible is expanding at a fast pace, and as a result, it has become much more difficult for regular customers to choose the appropriate cloud services. When selecting an appropriate service to use in a setting where there is a high degree of unpredictability, it is in the user's best interest to be able to deal with ambiguous information. This is because the Cloud service environment contains a great number of unknowns, which may prevent the user from making wise choices. In this paper, the authors propose a framework that they call the Optimal Service Choice and Priority of Cloud Computing (CC) Service. This methodology gives cloud customers the ability to evaluate the various service options available to them relying on QoS (Quality of Requirements) standards. The model employs a mixed approach to decision making that is based on many factors. The PROMETHEE is used for the purpose of ranking and prioritizing the QoS criteria, and to get the final rank of cloud services. The suggested methodology is a Multi-criteria decision making approach due to this problem contain many conflicting criteria. The PROMETHEE is integrated with neutrosophic environment to overcome uncertainty information. The application of methodology is provided.

Keywords: Cloud Service; MCDM; Neutrosophic Sets; Cloud Computing; Quality of Service

1. Introduction

Cloud computing has developed as a new emerging paradigm that has revolutionized the way that computing and service solutions are provided. This transition came about as a result of the explosive growth of service computing. The concept of computing in the cloud was derived from a wide variety of cutting-edge technology and has some characteristics with other types of computing systems. As comparison to more traditional forms of computing, cloud computing (CC) offers a number of important benefits, including considerable cost and efficiency savings. The CC paradigm provides three different levels of service, which are referred to as Software as a service (SaaS), Platform as a service (PaaS), and Infrastructure as a service (IaaS)[1]. These levels are determined by the requirements of the client. Users of CC are able to satisfy their information technology requirements by accessing virtual servers via the Network rather than constructing and maintaining their own computer infrastructure. Clients of cloud services benefit from this since they only have to pay for the resources they actually use, as opposed to the upfront expenses of hardware and software that are required by previous computing models. The elimination of a variety of administrative overheads in addition to the simplification of technological difficulties is another advantage of using CC for in-house information technology infrastructure. CC has become an excellent solution for businesses to run their operations as a result of these advantages. As a direct consequence of the capabilities offered by CC, several companies have been inspired to move their operations from on-premises data centers to those located in the cloud[2], [3].

As a consequence of this, many of the most successful information technology companies, such as Microsoft, Huawei, and Amazon, as well as private people, have shifted their operations from in-house to CC because of

the capabilities offered by CC. As a result of this, a multitude of services are now being offered via the cloud, and there are a number of cloud service suppliers located all over the globe[4], [5]. Most notably, the many cloud service suppliers deliver services that are comparable to one another but vary in the attributes they include, as well as the rates they charge and the levels of efficiency they give. When confronted with all of these different options and unknowns, cloud users who have made the decision to employ cloud services are faced with the challenge of selecting the finest cloud service provider that can meet all of their unique requirements[6], [7]. One of the most significant difficulties is figuring out how to choose a cloud service that meets the specific requirements of prospective customers in a way that is both highly effective and accurate[8], [9].

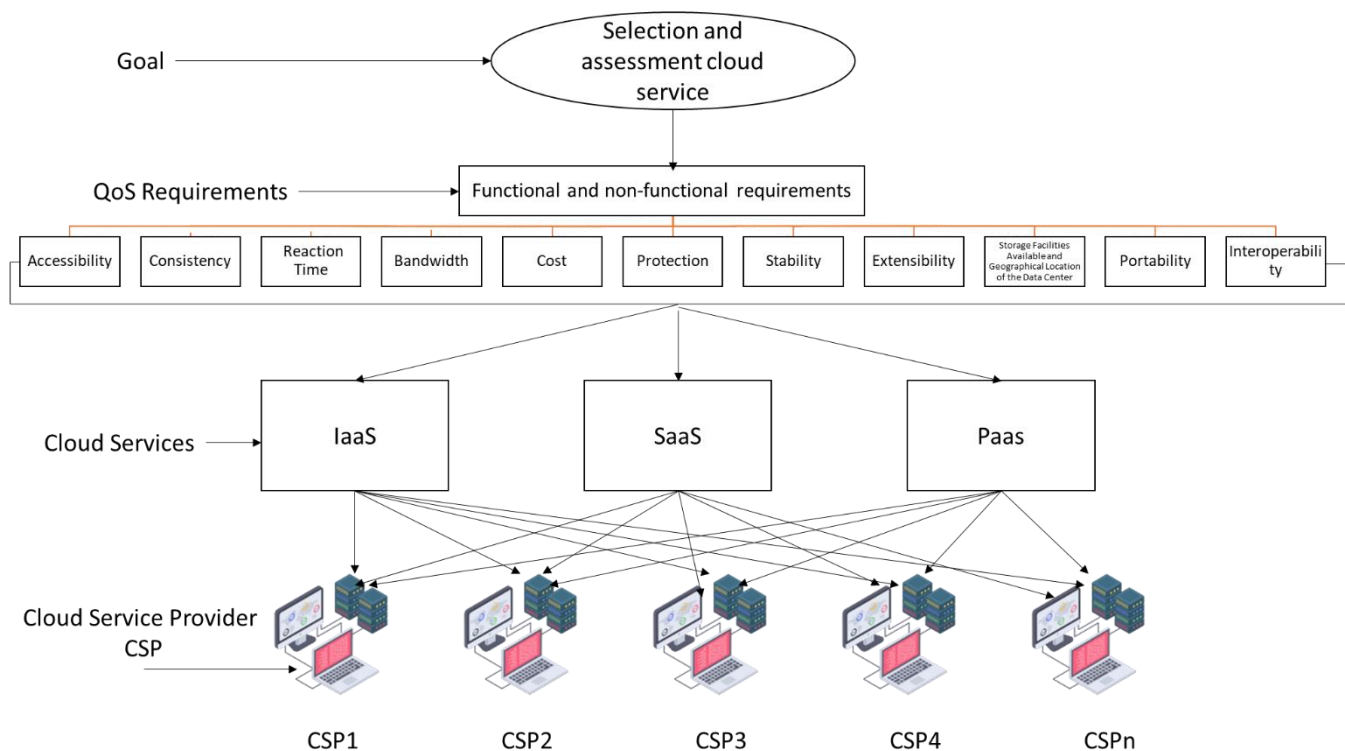


Figure 1: The cloud service provider situation.

In this respect, the most important criteria for rating and choosing between various cloud service providers constitute a comparable set. These criteria are concerned with quality of service. Quality of Service (QoS) refers to a collection of features, both functional and non-functional. The consumer of the cloud service will use these QoS features in order to make comparisons between the various cloud-based services[10], [11]. Cloud service choice is a common situation in which a cloud client or decision-maker chooses the cloud service that will best meet their needs based on a number of quality of service factors that are in conflict with one another. In addition, the process of selecting a cloud service comprises many distinct considerations, including a variety of Requirements, cloud service options, an interdependent link among requirements, and the synthesis of all information gathered that corresponds to each criterion[12], [13]. Consequently, the challenge of selecting a cloud service falls naturally within the heading of a multi-criteria decision making (MCDM) dilemma in figure 1.

Hence, in order to cope with client specifications and evaluate cloud services according to their capabilities, a more effective MCDM strategy may be necessary[14]. In this article, we provide a methodical evaluation approach for picking an ideal cloud service from a range of multiple comparable options, with the selection being made on the basis of the QoS requirements associated with cloud services. The customers are able to evaluate several cloud service offerings using this framework, according to their finest choice along with a number of other variables[15]–[17].

The following is the structure of this paper: In Section 2, we present the framework that will be used for selecting cloud services. In Section 3, an algorithmic representation of the methodology's actual application is provided for consideration. The last part of this paper, the conclusion, is found in Section 4.

2. The Neutrosophic PROMETHEE Framework

The PROMETHEE methodology, also known as the Preference Ranking Organization Method for Enrichment Evaluation, is an example of an outranking technique that offers a complete preorder on the set of actions that might be taken [18], [19].

These are the procedures that need to be taken in order to implement the PROMETHEE technique: (a) Creating an options and requirement matrix (b) Choosing a preferred function (c) Weighting requirements (d) Computing incomplete preorder (e) Computing complete preorder and (f) rating the actions [20]–[22].

First, you will need to standardize the information on the choice. That is, transforming $A = (a_{ij})_{mn}$ into $B = (b_{ij})_{mn}$ to normalise the data. If the decision is a non-beneficial factor, the information related to the choice should be altered by its complementary set; however, if the decision is an efficiency component, the information related to the decision should not be altered.

Build a preference function $P_j(O_i, O_r)$ of option O_i relative to O_r under the attribute C_j by using the following formula:

$$P_j(O_i, O_r) = \begin{cases} 0, & t \leq p \\ \frac{t-p}{q-p}, & p < t < q \\ 1, & t \geq q \end{cases} \quad (1)$$

Depending on the specifics of the situation, policymakers may also choose to develop preference functions on their own. t is the parameter of the priority function and represents the difference in criteria values among scheme O_r and scheme O_i .

Define the index of priority $\beta(O_i, O_r)$

$$\beta(O_i, O_r) = \frac{\sum_{j=1}^n w_j P_j(O_i, O_r)}{\sum_{j=1}^n w_j} = \sum_{j=1}^n w_j P_j(O_i, O_r) \quad (2)$$

Define the inflow, outflow and the net flow

$$\Delta = \sum_{r=1}^n \beta(O_i, O_r) \quad (3)$$

$$\nabla = \sum_{r=1}^n \beta(O_r, O_i) \quad (4)$$

$$\exists = \Delta - \nabla \quad (5)$$

Rank the alternatives based on the net flow

3. Applications

In this section, this paper provides an application of selecting best provider from multiple providers and conflicting criteria. This study gather three experts who have experience in cloud computing to evaluate the criteria and providers. Three experts gather 11 criteria and five alternative to apply the suggested neutrosophic methodology. There are 11 criteria described in table 1. Let experts used the single value neutrosophic numbers (SVNNs) to evaluate the criteria and alternatives [23]. First experts evaluate the criteria. Then integrate the preference value of experts to compute the weights of criteria. Figure 1 shows the weights of criteria.

Table 1: The description of criteria[24]–[27].

Criteria	Description
Accessibility	The amount of time, measured in percentages, that a cloud service is really accessible through a network is referred to as its accessibility.
Consistency	In cloud computing, "consistency" defined as the degree to which a cloud service continues to function normally while being subjected to a certain range of operating conditions over a predetermined amount of time. It is computed as the product of the cloud service provider's guaranteed mean prediction error and the chance of service failure for the given amount of time.
Reaction Time	Reaction time is an indicator that provides a more condensed overview of the entire functionality of a cloud service. It sheds light on the speed with which a cloud service may be made accessible for the purpose of utilization. Hence, the time it takes to get a response message after submitting a request message is considered to be the response time.
Bandwidth	The quantity of work that a cloud service is able to finish in a certain length of time is represented by the bandwidth. When referring to a system that processes transactions, the throughput is often measured in transactions per second.
Cost	The cost is always a significant component in the whole decision-making process. With the cloud computing model, the user only pays for the resources they really utilize. The cost of using cloud computing services is determined by two fundamental factors: acquisition and on-demand pricing.
Protection	Once it comes to storing sensitive corporate data on the cloud, safety is one of the most important characteristics to look for. A collection of control-based technologies and policies meant to conform to the regulatory compliance regulations and secure information, data applications, and infrastructure linked with the use of cloud computing is what we call cloud computing security.
Stability	In the Service Level Agreement (SLA) for a cloud service, the word "variance" refers to the stability of the service's operation. This demonstrates the fluctuation in the mean amount of time required to read and write data using a cloud storage service.
Extensibility	Scaling is the process of effectively assigning and coordinating the resources of an app in order to reduce the amount of conflict that exists. The ability of a cloud service to be scaled up when demand is highest is what is meant when we talk about its scalability.
Storage Facilities Available and Geographical Location of the Data Center	When it comes to computing the operations, there are two different kinds of disc sizes. They are referred to as internal and exterior. The internal storage disks, on the other hand, are housed on the exact same physical hardware as the calculated

	instance itself. In contrast hand, the external storage portions are located on a system that is external to the computer. Computed applications more often than not have data centers in several locations, which helps in determining which operations are distributed in calculated instances.
Portability	The capacity to shift an object from one device to another while maintaining its functionality on the victim machine is what we mean when we talk about portability. Within the framework of cloud computing, portability can be broken down into two distinct subdomains: the portability of data and the portability of applications.
Interoperability	It specifies the capacity of a service or app to communicate with other services and applications inside a system or to share information with those other services and applications. Interoperability is described in the context of cloud technology as the capacity of personal, commercial, and mixed clouds to comprehend the app of the other kind of cloud.

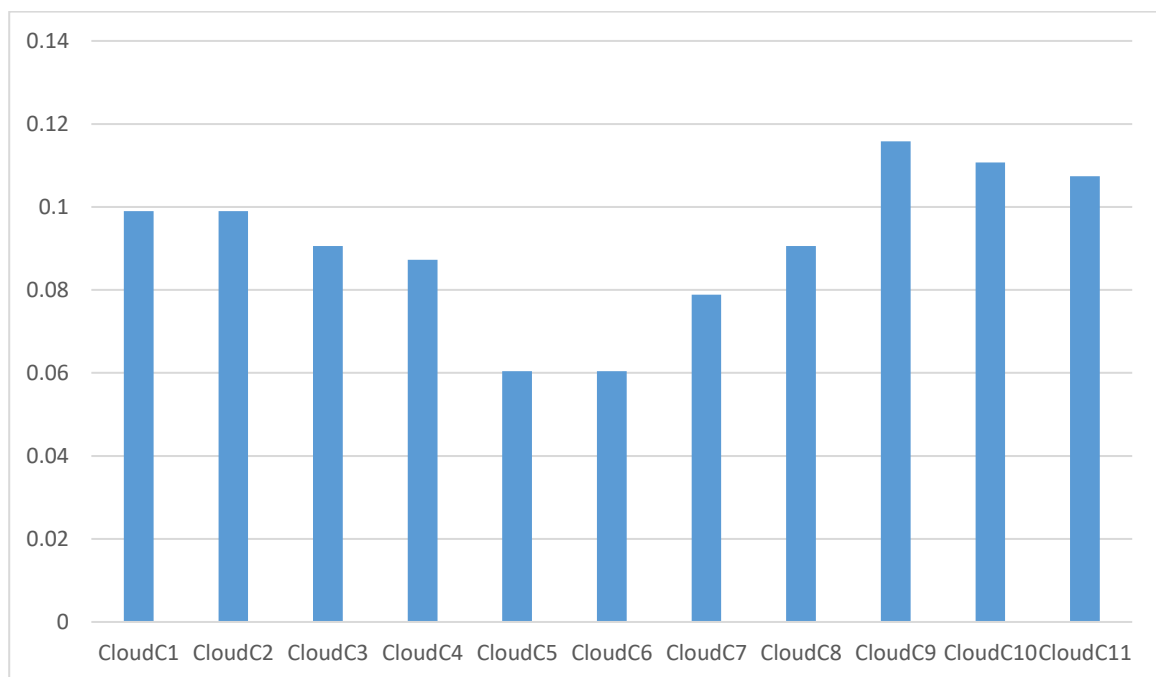


Figure 2: The Weights of 11 feature of cloud computing service.

Then let experts to evaluate the alternatives and criteria to build the decision matrix. Table 2 shows these assessment. Then normalize the decision matrix. Then build the preference function. Then compute the index of priority. Then compute the leaving and entering criteria (in flow and out flow). Then compute the difference between inflow and outflow to compute the net flow. Then rank the alternative based on the highest value of net flow. The figure 3 shows the rank of cloud service provider. The provider 3 is the best alternative and provider 2 is the lowest alternative.

Table 2: The decision matrix.

Expert 1	Cloud c1	Cloud c2	Cloud c3	Cloud c4	Cloud c5	Cloud c6	Cloud c7	Cloud c8	Cloud c9	Cloud c10	Cloud c11
Cloud _{A1}	(0.4,0.3,0.7)	(0.8,0.3,0.1)	(0.4,0.3,0.7)	(0.4,0.3,0.7)	(0.1,0.2,0.8)	(0.1,0.2,0.8)	(0.6,0.4,0.3)	(0.4,0.3,0.7)	(0.8,0.3,0.1)	(0.8,0.3,0.1)	(0.4,0.3,0.7)
Cloud _{A2}	(0.8,0.3,0.1)	(0.7,0.3,0.3)	(0.7,0.3,0.3)	(0.8,0.3,0.1)	(0.4,0.3,0.7)	(0.4,0.3,0.7)	(0.4,0.3,0.7)	(0.4,0.3,0.7)	(0.4,0.3,0.7)	(0.4,0.3,0.7)	(0.6,0.4,0.3)
Cloud _{A3}	(0.4,0.3,0.7)	(0.4,0.3,0.7)	(0.4,0.3,0.7)	(0.4,0.3,0.7)	(0.1,0.2,0.8)	(0.1,0.2,0.8)	(0.4,0.3,0.7)	(0.6,0.4,0.3)	(0.7,0.3,0.3)	(0.7,0.3,0.3)	(0.7,0.3,0.3)
Cloud _{A4}	(0.7,0.3,0.3)	(0.8,0.3,0.1)	(0.6,0.4,0.3)	(0.4,0.3,0.7)	(0.1,0.2,0.8)	(0.4,0.3,0.7)	(0.6,0.4,0.3)	(0.4,0.3,0.7)	(0.4,0.3,0.7)	(0.8,0.3,0.1)	(0.4,0.3,0.7)
Cloud _{A5}	(0.4,0.3,0.7)	(0.7,0.3,0.3)	(0.4,0.3,0.7)	(0.8,0.3,0.1)	(0.4,0.3,0.7)	(0.4,0.3,0.7)	(0.4,0.3,0.7)	(0.4,0.3,0.7)	(0.8,0.3,0.1)	(0.4,0.3,0.7)	(0.6,0.4,0.3)
Expert 2	Cloud c1	Cloud c2	Cloud c3	Cloud c4	Cloud c5	Cloud c6	Cloud c7	Cloud c8	Cloud c9	Cloud c10	Cloud c11
Cloud _{A1}	(0.4,0.3,0.7)	(0.8,0.3,0.1)	(0.4,0.3,0.7)	(0.4,0.3,0.7)	(0.1,0.2,0.8)	(0.4,0.3,0.7)	(0.6,0.4,0.3)	(0.8,0.3,0.1)	(0.8,0.3,0.1)	(0.8,0.3,0.1)	(0.8,0.3,0.1)
Cloud _{A2}	(0.8,0.3,0.1)	(0.7,0.3,0.3)	(0.7,0.3,0.3)	(0.8,0.3,0.1)	(0.8,0.3,0.1)	(0.4,0.3,0.7)	(0.4,0.3,0.7)	(0.4,0.3,0.7)	(0.4,0.3,0.7)	(0.4,0.3,0.7)	(0.4,0.3,0.7)
Cloud _{A3}	(0.4,0.3,0.7)	(0.4,0.3,0.7)	(0.8,0.3,0.1)	(0.8,0.3,0.1)	(0.1,0.2,0.8)	(0.1,0.2,0.8)	(0.4,0.3,0.7)	(0.6,0.4,0.3)	(0.7,0.3,0.3)	(0.7,0.3,0.3)	(0.4,0.3,0.7)
Cloud _{A4}	(0.8,0.3,0.1)	(0.8,0.3,0.1)	(0.6,0.4,0.3)	(0.4,0.3,0.7)	(0.8,0.3,0.1)	(0.4,0.3,0.7)	(0.8,0.3,0.1)	(0.4,0.3,0.7)	(0.4,0.3,0.7)	(0.8,0.3,0.1)	(0.4,0.3,0.7)
Cloud _{A5}	(0.4,0.3,0.7)	(0.8,0.3,0.1)	(0.4,0.3,0.7)	(0.8,0.3,0.1)	(0.8,0.3,0.1)	(0.4,0.3,0.7)	(0.4,0.3,0.7)	(0.8,0.3,0.1)	(0.4,0.3,0.7)	(0.4,0.3,0.7)	(0.6,0.4,0.3)
Expert 3	Cloud c1	Cloud c2	Cloud c3	Cloud c4	Cloud c5	Cloud c6	Cloud c7	Cloud c8	Cloud c9	Cloud c10	Cloud c11
Cloud _{A1}	(0.7,0.3,0.3)	(0.8,0.3,0.1)	(0.4,0.3,0.7)	(0.7,0.3,0.3)	(0.1,0.2,0.8)	(0.1,0.2,0.8)	(0.7,0.3,0.3)	(0.4,0.3,0.7)	(0.7,0.3,0.3)	(0.8,0.3,0.1)	(0.7,0.3,0.3)
Cloud _{A2}	(0.8,0.3,0.1)	(0.7,0.3,0.3)	(0.7,0.3,0.3)	(0.8,0.3,0.1)	(0.7,0.3,0.3)	(0.4,0.3,0.7)	(0.7,0.3,0.3)	(0.4,0.3,0.7)	(0.7,0.3,0.3)	(0.4,0.3,0.7)	(0.7,0.3,0.3)
Cloud _{A3}	(0.4,0.3,0.7)	(0.4,0.3,0.7)	(0.7,0.3,0.3)	(0.4,0.3,0.7)	(0.7,0.3,0.3)	(0.7,0.3,0.3)	(0.4,0.3,0.7)	(0.6,0.4,0.3)	(0.7,0.3,0.3)	(0.7,0.3,0.3)	(0.7,0.3,0.3)
Cloud _{A4}	(0.7,0.3,0.3)	(0.7,0.3,0.3)	(0.6,0.4,0.3)	(0.7,0.3,0.3)	(0.1,0.2,0.8)	(0.7,0.3,0.3)	(0.6,0.4,0.3)	(0.7,0.3,0.3)	(0.4,0.3,0.7)	(0.7,0.3,0.3)	(0.4,0.3,0.7)
Cloud _{A5}	(0.4,0.3,0.7)	(0.7,0.3,0.3)	(0.7,0.3,0.3)	(0.8,0.3,0.1)	(0.7,0.3,0.3)	(0.4,0.3,0.7)	(0.7,0.3,0.3)	(0.4,0.3,0.7)	(0.7,0.3,0.3)	(0.4,0.3,0.7)	(0.7,0.3,0.3)

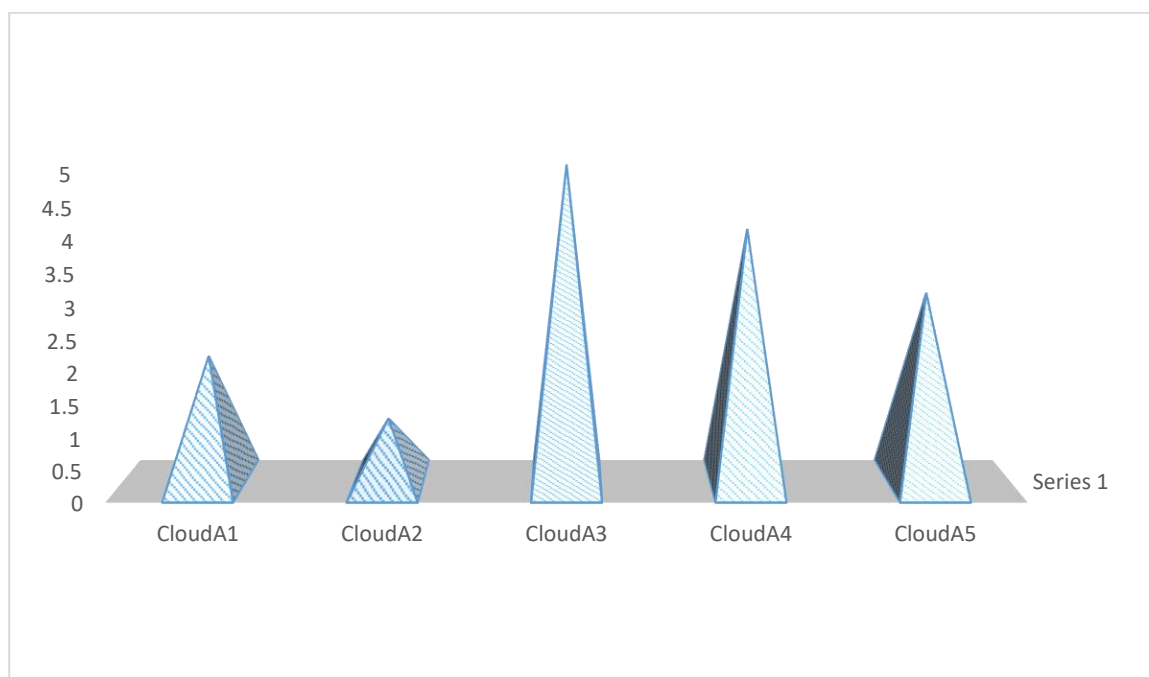


Figure 3: The order of 5 cloud service provider

4. Conclusions

During the last several years, CC has seen a meteoric rise in popularity as a potentially game-changing Internet technology owing to the financial and technological advantages it offers over more traditional modes of computer operation. Users are able to purchase computer resources as and when they need them using a pay-as-you-go pricing model while using CC. As a result of this, a multitude of services are now being offered via the cloud, and there are a number of cloud service providers located all over the globe. Most notably, the many cloud service providers offer services that are comparable to one another but vary in the attributes they include, as well as the rates they charge and the levels of functionality they give. When confronted with all of these different options and unknowns, cloud users who have made the decision to employ cloud services are faced with the challenge of selecting the finest cloud service provider that can meet all of their unique requirements. The choice of a cloud service is presently receiving a lot of serious attention as a result of the increasing demand for cloud computing and the commercial demand for cloud services. Despite the fact that a variety of decision-making approaches have been used in the past to assist cloud customers in locating a cloud service that is appropriate for their needs, some uncertainties in the cloud environment, motivate more research. In this piece of work, we examined the challenge of selecting a cloud service in a setting where the goals of customers are always shifting. This paper employed the neutrosophic sets with the PROMETHEE method to select best alternative. This paper used 11 criteria and 5 cloud service provider.

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